

PUBLIC RELEASE

United States Air Force Scientific Advisory Board



Executive Summary on Space Survivability

**SAB-TR-06-03
30 June 2006**

DISTRIBUTION AUTHORIZED
In accordance with AFI 61-204 and DODD 5230.24, distribution statement A, this document is approved for public release; distribution is unlimited.

PUBLIC RELEASE

PUBLIC RELEASE

This report is a product of the United States Air Force (USAF) Scientific Advisory Board (SAB) study team on *Space Survivability*. Statements, opinions, findings, recommendations, and conclusions contained in this report are those of the study committee and do not necessarily represent the official position of the USAF or the Department of Defense.

PUBLIC RELEASE

Foreword

The USAF is vitally dependent on capabilities delivered or enabled by military, Intelligence Community (IC), civil, and some commercially-available space assets. Vulnerabilities in our space systems could result in the loss of critical space-based capabilities, such as communications, Positioning, Navigation and Timing (PNT), and Intelligence, Surveillance, and Reconnaissance (ISR) that directly support our warfighters. Threats to our space systems, including assets in space, on the ground, and links between them, appear to be increasing. It would be expensive and difficult to replace these assets.

This study addresses the spectrum of our military reliance on space systems, the threats to those systems, their vulnerabilities, and appropriate response actions. It also considers the current state of integration of the nation's ground and space capabilities for rapid detection, assessment of and response to potential attack and offers recommendations on technological and operational options for improving the survivability of current and future United States (U.S.) space systems. This study was conducted in response to a request by the Secretary of the Air Force (SECAF) and the Chief of Staff of the Air Force (CSAF).

The Space Survivability study team conducted an extensive set of visits to all relevant USAF and IC organizations and key operations centers, as well as key joint commands. The team reviewed numerous briefings concerning the threat and current operations, systems, and procedures, as well as proposed future survivability improvements. The assistance of these organizations was essential to the completion of our effort. It was their involvement that guided the study team toward the findings, concepts, conclusions, and recommendations that comprise this study. The study team greatly appreciates the cooperation of these organizations, and acknowledges the valuable contributions their efforts made to this study.

The undersigned also wish to acknowledge the outstanding effort put forth by the SAB Secretariat, the members of the Space Survivability study team, the study Executive Officers, and the Technical Writer in the preparation of this study – whatever value is found in this work is attributable to them.

A handwritten signature in black ink, appearing to read 'Grant Stokes', with a stylized, sweeping flourish at the end.

Dr. Grant Stokes
Space Survivability Study Chair

A handwritten signature in black ink, appearing to read 'Howard K. Schue', with a long, horizontal, wavy line extending from the end.

Mr. Howard K. Schue
Space Survivability Study Vice Chair

Table of Contents

Foreword.....	i
Table of Contents	ii
Introduction.....	1
Study Approach	1
Summary of Findings.....	1
Recommendations.....	2
Appendix A: Terms of Reference	4
Appendix B: Study Team Members.....	6
Appendix C: Acronyms and Abbreviations	7

United States Scientific Board Report on Space Survivability

Introduction

The USAF is vitally dependent on capabilities delivered or enabled by military, IC, civil, and some commercially-available space assets. This study addresses the spectrum of our military reliance on space systems, the threats to those systems, their vulnerabilities, and appropriate response actions. It also considers the current state of integration of the nation's ground and space capabilities for rapid detection, assessment of and response to potential attack and offers recommendations on technological and operational options for improving the survivability of current and future United States space systems. This study was conducted in response to a request by the SECAF and the CSAF.

Study Approach

The Space Survivability study team conducted an extensive set of visits to all relevant USAF and IC organizations and key operations centers, as well as key joint commands. The team reviewed numerous briefings and over 200 previous studies concerning the threat and current operations, systems, and procedures, as well as proposed future survivability improvements. These materials varied widely in currency, scope, depth, and technical rigor. They also differed in their consideration of response actions, and the extent to which they addressed the impact on users of the space systems. Overall, these visits and studies provided a valuable foundation for the work of the study team.

Summary of Findings

The capability of the U.S. to project military power globally relies on key tenets, including enhanced lethality of light forces, global situation awareness, information dominance, and precision engagement with little collateral damage. These asymmetric capabilities in turn are fundamentally enabled by, and reliant on, space-provided and space-delivered services. The space services include ISR, PNT, communications, missile warning, environmental monitoring, and nuclear detonation detection and location. This space-provided advantage possessed by the U.S. has led to a scaling of the military enterprise, including the logistics chain, manning, and force composition, so that it has become dependent upon capabilities provided by space-based assets. Simultaneously, the availability of alternatives and of redundant capabilities has diminished.

The asymmetric advantage possessed by the U.S. and its increasing reliance on space systems has been well demonstrated over the past 15 years of almost continuous conflicts, starting with OPERATION DESERT STORM and continuing today with OPERATION IRAQI FREEDOM. This advantage was perfected and demonstrated during a time, following the collapse of the Soviet Union, when there have been essentially no credible threats to space assets. However, in the current epoch potential adversaries, from terrorist cells to potential peer competitors, have clearly noticed the extent to which the U.S. leverages its space capabilities to produce military effects. That notice had led to the development, and in some cases testing and operations, of capabilities intended to impede operation of space assets. Potential threats include attacks on ground stations and links, laser weapons, jamming, nuclear detonations, and kinetic kill by microsats and other space-based systems. Many of these capabilities have been developed to the

PUBLIC RELEASE

point that employment will not be a question of technology, but rather of intent. The development cycle time for threats to U.S. space assets is significantly shorter than the development cycle time for U.S. space systems. Our assessment is that space is no longer a sanctuary.

The benign threat environment of the past 15 years has led to a degree of complacency concerning the survivability of our space systems. During this period, the capabilities that the U.S. possessed during the Cold War to assess and potentially counter threats to space systems have diminished. These capabilities include intelligence collection and analysis, Space Situation Awareness (SSA), training of space system operators and warfighters in an environment of degraded space services, and a robust Science and Technology (S&T) program for the development of survivability technologies.

In establishing the recommendations to address the quickly changing threat environment and the degrading survivability posture of the nation's space capability, the team recognized the USAF's successful Red/Blue Team for air vehicle survivability program. This effort was started during the 1970's in response to the high losses experienced in Vietnam, and over the past 30+ years has successfully reduced the losses to essentially zero. The recommendations of this study draw upon the proven elements of the Red/Blue Team approach.

Recommendations

At the outset of this study, the team recognized that in order to be accepted and implemented, the recommendations had to be affordable and largely executable within the authority of the USAF. The following recommendations are intended to guide the establishment of a long-term space survivability program, while identifying areas where immediate efforts will yield high payoff.

Recommendation #1 – Establish independent Red Team/Blue Team structure for space survivability. This recommendation will require the personal interest of SECDEF and CSAF to implement and succeed. The Red Team is intended to follow the successful model established by the Air Vehicle Survivability process of providing an objective, respected and enduring presence to guide the space survivability mission. The Red Team will challenge and aid the evolution of the space architecture. The Air Force's Blue Team is comprised of the Air Force enterprise that develops new approaches and systems for space survivability to counter current and emerging threats.

Recommendation #2 – Immediately establish a *responsive* SSA capability that meets space survivability needs. The use of data from existing systems can quickly improve the nation's SSA capability. The first step is to knock down impediments to data access for operators and tool developers and establish the "need to share." Once the data are made available, a scalable, net-centric architecture for SSA enabling early capability insertion and rapid incremental evolution should be developed as the basis of the SSA system. Finally, the program of record for space survivability, Rapid Attack Interference Detection and Reporting System (RAIDRS), should be incorporated into the net-centric architecture described above.

Recommendation #3 – Engage the community to increase the survivability of the entire space enterprise. This recommendation recognizes that the USAF provides many of the key

PUBLIC RELEASE

elements of the nation's space enterprise, but that there are other organizations that control capabilities that the USAF is dependent upon to conduct operations. In that vein, the USAF should work to establish integrated space survivability operations to include military IC, civil, and commercial space systems. In support of that role, the USAF should provide the 14th Air Force and Joint Space Operations Center (JSpOC) with adequate resources to execute their leadership in space survivability operations. In addition, the USAF should develop an integrated space survivability plan and architecture, and coordinate survivability Research and Development (R&D) with mission partners. The S&T portfolio and near-term acquisitions should be adjusted to strengthen space system survivability attributes.

Recommendation #4 – USAF should exert influence to increase priority for strategic space intelligence. The USAF should request that more intelligence community support be focused on threats to space systems and the intent to use them. This is intended to develop a better basis for system requirements for systems that will impact the nation's capabilities for more than 25 years.

Recommendation #5 – Develop, mature, and practice space survivability strategies, Concept of Operations, and Tactics, Techniques and Procedures (TTPs) for operators of space systems. Operators of space systems must be trained to operate in degraded space environments. Integrated operational expertise and tactics should be developed across the military, IC, civil, and commercial systems. In addition, plausible, but not necessarily validated threats should be used in the training.

Recommendation #6 – Train and test warfighters to fight with degraded space capabilities. USAF commands should train and test to ensure mission effectiveness in degraded space capabilities environments. In addition, the USAF should work with the joint community to develop doctrine, TTPs, and exercises for operations in degraded space services environments. Plausible, but not necessarily validated threats should be used in the training.

Appendix A: Terms of Reference

Here below are the full Terms of Reference for the Space Survivability Study as directed by the Secretary of the Air Force:

SECAF approved 10 Jan 06 Approved for Public Release by SAF/PAX 6 Feb 06

USAF Scientific Advisory Board
Small Summer Study
FY 2006
Space Survivability
Terms of Reference

Background

The USAF is vitally dependent on capabilities delivered or enabled by military, intelligence community and some commercially available space assets. In addition, the Air Force may be tasked to defend high value space assets in the event of hostilities. Ground stations, orbiting assets and the links between them are vulnerable to conventional and non-conventional countermeasures. Vulnerabilities include, for example, attacks on ground stations and links, and the effects of laser weapons, jamming, nuclear detonations and kinetic kill by microsats and other space-based systems. These vulnerabilities could be critical in that both ground stations and satellites are difficult and expensive to replace rapidly. In addition, the corrosive effects of the space environment may degrade system capabilities in ways not immediately distinguishable from intentional acts.

Currently the Air Force is investing in and maintaining many critical space systems and their infrastructures. The Air Force is also investing in several programs on SSA, OCS, and DCS. These programs are apparently not well integrated in either planning, execution or staffing. The liability of this is to leave some important capabilities unmet, potentially inducing critical vulnerabilities. Taken together, these Air Force programs must comprise an integrated and comprehensive set of options for gaining and maintaining survivability of the components of U.S. national security space systems, and for the planned graceful degradation or substitution if necessary.

Study Products

Briefing to SAF/OS and AF/CC in June 2006. Publish report in October 2006.

Charter

PUBLIC RELEASE

- Develop a comprehensive system understanding of the spectrum of reliance on space systems, threats, vulnerabilities and responses options needed.
- Review and assess previous studies, current programs and R&D activities by government and contractor organizations.
- Determine how well these efforts are addressing the integration of all ground and space elements for rapid detection, assessment of and response to potential attack.
- Make recommendations on technological and operational options, including an assessment of the existing portfolio of SSA, OCS, and DCS programs for mitigating current and future U.S. space vulnerabilities.

PUBLIC RELEASE

Appendix B: Study Team Members

Study Chair: Dr. Grant Stokes

Vice Chair: Mr. Howard Schue

Members:

Dr. John Betz

Dr. John Brock

Dr. L. S. "Doc" Dougherty

Dr. Jack Fleischman

Dr. Dan Hastings

Mr. George Hull

Dr. Rami Razouk

Dr. David Whelan

Dr. Joan Woodard

General Officer Participant:

Brig Gen Larry James

Red Team:

Mrs. Natalie Crawford

VADM David Frost (USN, ret)

Dr. Tony Pensa

Ms. Heidi Shyu

Government Participant:

Mr. Emil Martinsek

Support Staff:

Ms. Beverly Freeman

Lt Col Kyle Gresham

Maj Brian K. Bailey

Maj Michael Borbath

Maj Brian Bracy

Maj Dan McGibney

Maj Ed Ryan

Appendix C: Acronyms and Abbreviations

CSAF	Chief of Staff of the Air Force
DCS	Defensive Counter Space
IC	Intelligence Community
ISR	Intelligence, Surveillance and Reconnaissance
JSpOC	Joint Space Operations Center
OCS	Offensive Counter Space
PNT	Position, Navigation and Timing
R&D	Research and Development
RAIDRS	Rapid Attack Interference Detection and Reporting System
SAB	Scientific Advisory Board
S&T	Science and Technology
SECAF	Secretary of the Air Force
SSA	Space Situational Awareness
TTPs	Tactics, Techniques and Procedures
U.S.	United States
USAF	United States Air Force

PUBLIC RELEASE

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188		
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 30-06-2006		2. REPORT TYPE Final		3. DATES COVERED (From - To) 01-10-2005 to 30-06-2006	
4. TITLE AND SUBTITLE Space Survivability		5a. CONTRACT NUMBER N/A			
		5b. GRANT NUMBER N/A			
		5c. PROGRAM ELEMENT NUMBER N/A			
6. AUTHOR(S) Dr. Grant H. Stokes, Mr. Howard K. Schue, Dr. John Betz, Dr. John Brock, Dr. L.S. "Doc" Dougherty, Dr. Jack Fleischman, Dr. Dan Hastings, Mr. George Hull, Dr. Rami Razouk, Dr. David Whelan, and Dr. Joan Woodard		5d. PROJECT NUMBER N/A			
		5e. TASK NUMBER N/A			
		5f. WORK UNIT NUMBER N/A			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) HQ USAF/SB 1180 Air Force Pentagon RM 5D982 Washington, DC 20330-1180		8. PERFORMING ORGANIZATION REPORT NUMBER SAB-TR-06-03			
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SAF/OS, AF/CC 1670 Air Force Pentagon Washington, DC 20330-1670		10. SPONSOR/MONITOR'S ACRONYM(S) N/A			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) N/A			
12. DISTRIBUTION / AVAILABILITY STATEMENT A Approved for Public Release; Distribution is Unlimited					
13. SUPPLEMENTARY NOTES N/A					
14. ABSTRACT The United States Air Force is vitally dependent on capabilities delivered or enabled by military, Intelligence Community, civil, and some commercially-available space assets. Vulnerabilities in our space systems could result in the loss of critical space-based capabilities, such as communications, positioning, navigation and timing, and ISR that directly support our warfighters. Our ground stations, launch sites, satellites, and the links between them are vulnerable to direct physical attacks, laser weapons, jamming, nuclear detonations and kinetic kill by space-based systems; these threats appear to be increasing. Our ground stations and satellites are difficult and expensive to replace and would require years - sometimes decades - to be fully reconstituted. This study addresses the spectrum of our military reliance on space systems, the threats to those systems, their vulnerabilities, and appropriate response actions. It also considers the current state of integration of the nation's ground and space capabilities for rapid detection, assessment of and response to potential attack and offers recommendations on technological and operational options for improving the survivability of current and future U.S. space systems. This study was conducted in response to a request by the Secretary of the Air Force and the Chief of Staff of the Air Force.					
15. SUBJECT TERMS Space Survivability, Sensor, ISR, Space Situational Awareness, Defensive Counterspace, Offensive Counterspace, SSA, DCS, OCS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED	Unclassified Unlimited	12	HQ USAF/SB
					19b. TELEPHONE NUMBER (include area code) 703-697-4811

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

PUBLIC RELEASE

PUBLIC RELEASE

PUBLIC RELEASE